MINISTRY OF EDUCATION, SINGAPORE
in collaboration with
UNIVERSITY OF CAMBRIDGE LOCAL EXAMINATIONS SYNDICATE
General Certificate of Education Ordinary Level

CANDIDATE NAME

CENTRE NUMBER | S | | | | |

INDEX NUMBER | | | | |

Paper 3 Chemistry

October/November 2016

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, index number and name on all the work you hand in.
You may use an HB pencil for any diagrams, graphs, tables or rough working.
Write in dark blue or black pen.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.
Write your answers in the spaces provided on the question paper.

Section B
Answer any **two** questions.
Write your answers in the spaces provided on the question paper.

A copy of the Data Sheet is printed on page 15.
A copy of the Periodic Table is printed on page 16.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Section A

Answer **all** the questions in the spaces provided.

1 **(a)** Name the pieces of apparatus most suitable to complete the following laboratory actions:

(i) separate a precipitate from a solution,

..... [1]

(ii) measure exactly 22.7 cm^3 of solution into a beaker,

..... [1]

(iii) collect and measure the volume of a water-soluble gas,

..... [1]

(iv) add exactly 25 cm^3 of solution to each of several beakers.

..... [1]

(b) The apparatus shown in Fig. 1.1 can be used to separate pure water from sea water.

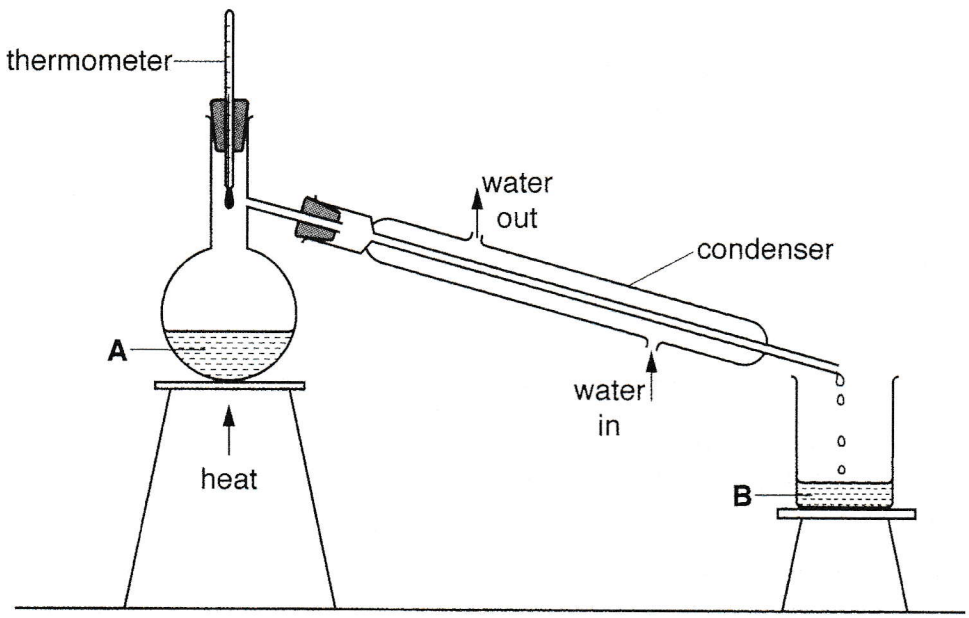


Fig. 1.1

(i) State the general name for this method of separation.

.....[1]

(ii) Predict the reading on the thermometer during the separation.

..... [1]

(iii) State the purpose of the water in the condenser.

.....[1]

(iv) Two samples are taken, one at point **A** and another at point **B**. Each is placed in a separate glass evaporating dish and heated to dryness. The sample from **A** left a white solid and the sample from **B** left no residue.

Explain these **two** observations.

.....

.....

.....[2]

2 Table 2.1 lists the number of protons, neutrons and electrons in several different particles.

Table 2.1

particle (not chemical symbols)	number of protons	number of neutrons	number of electrons
C	1	0	1
D	3	3	2
E	7	7	7
F	8	9	8
G	8	10	8
H	9	10	10

Which of the particles, **C**, **D**, **E**, **F**, **G** and **H** in Table 2.1, fit each of the following descriptions?

(a) an atom with a mass number of 18 .....

(b) an atom with 5 electrons in its outer shell .....

(c) an ion of a metal .....

(d) atoms of isotopes of the same element ..... and .....

(e) a negatively charged ion .....

[5]

3 **(a)** State the order by which the elements are arranged in the Periodic Table.

.....[1]

(b) State what is identical in the electronic structures of elements in the same

(i) group,

.....[1]

(ii) period.

.....[1]

(c) Explain why the elements in Group II have similar chemical properties.

.....

.....[1]

(d) Write the name and chemical formula of a compound formed when an element from Group VI combines with an element from

(i) Group I,

name of compound ..... chemical formula ..... [1]

(ii) Group II.

name of compound ..... chemical formula ..... [1]

4 You have samples of three metals and an aqueous nitrate solution of each metal. Only **one** of these metals is positioned above hydrogen in a reactivity series.

(a) Describe how to use dilute sulfuric acid to identify the most reactive of these three metals.

.....

.....

.....[1]

(b) Describe a chemical test that will show the presence of copper(II) ions in any one of the nitrate solutions.

.....

.....

.....[2]

5 **(a)** Acid **J** has a relative molecular mass of 98. A 200 cm^3 aqueous sample contains 196 g of **J**.

(i) Calculate the concentration of **J** in g/dm^3.

concentration = ... g/dm^3 [1]

(ii) Calculate the concentration of **J** in mol/dm^3.

concentration = ... mol/dm^3 [1]

(b) When **J** is mixed with acidified aqueous barium nitrate, a white precipitate **K** forms.

(i) Barium carbonate is white and insoluble in water. State why **K** cannot be barium carbonate.

.....[1]

(ii) Suggest the identity of **K**.

.....[1]

(iii) Write a balanced chemical equation, including state symbols, for the reaction of **J** with aqueous barium nitrate.

.....[3]

6 A complex compound, serpentine, is formed in the Earth's crust from fayalite, Fe_2SiO_4. In the first stage of its formation hydrogen is released.

This reaction is highly exothermic and could be adapted to produce hydrogen quickly on an enormous scale.

(a) Define the term *exothermic*.

.....[1]

(b) The burning of hydrogen is a source of clean energy. The burning of fossil fuels is not a source of clean energy.

Suggest the meaning of the term *clean energy*.

.....

.....[2]

(c) The following equation describes the formation of hydrogen from fayalite.

$$3Fe_2SiO_4 + 2H_2O \rightarrow 2Fe_3O_4 + 3SiO_2 + 2H_2$$

[Relative atomic masses: A_r: H, 1; O, 16; Si, 28; Fe, 56]
[The volume of one mole of any gas is 24 dm^3 at room temperature and pressure.]

(i) Calculate the relative formula mass of fayalite, Fe_2SiO_4.

relative formula mass = ...[1]

(ii) Calculate the mass of fayalite needed to produce 1000 g of hydrogen.

mass of fayalite = ...g [2]

(iii) Calculate the volume of 1000 g of hydrogen.

volume of hydrogen = ... dm^3 [2]

7 Fig. 7.1 describes some of the properties and reactions of two hydrocarbons, **L** and **M**.
[Relative atomic masses: A_r: H, 1; C, 12; Cl, 35.5; Br, 80]

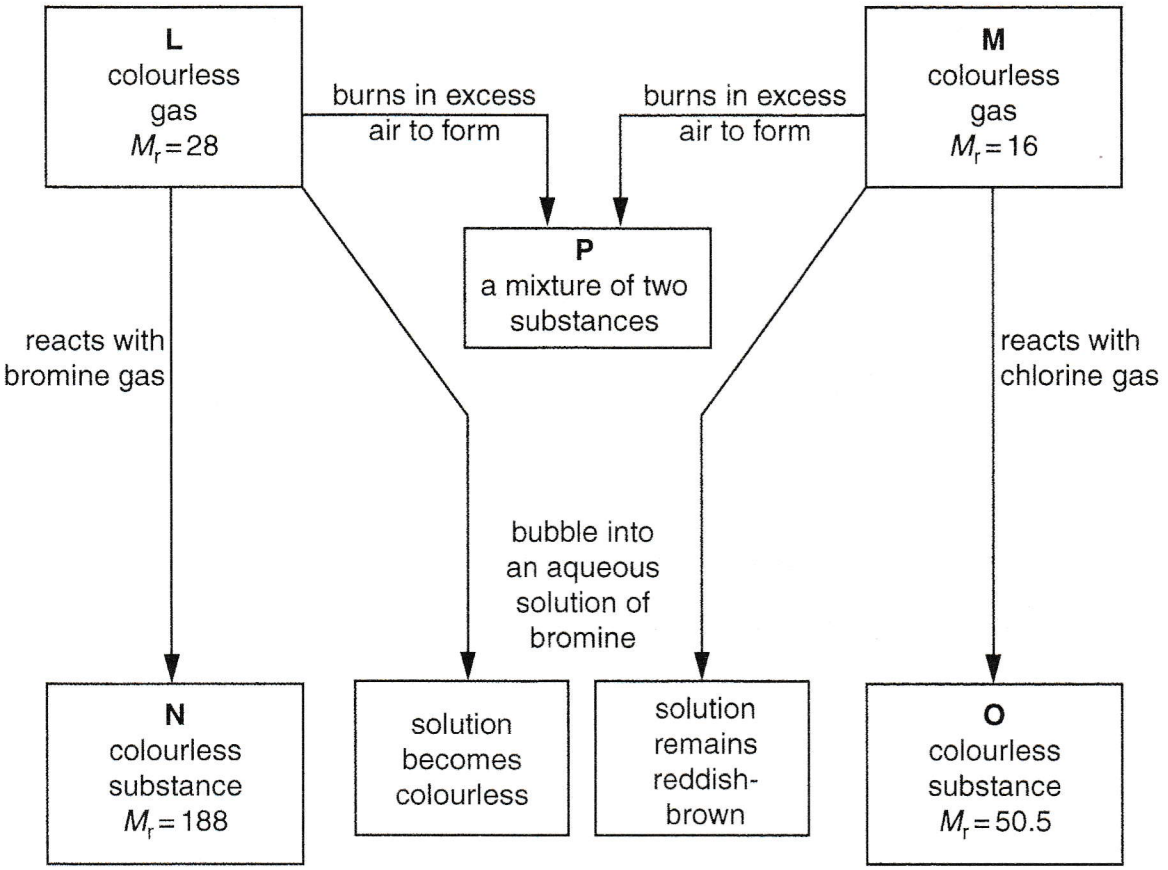


Fig. 7.1

(a) Suggest the identity of substances **L**, **M**, **N**, **O** and both substances in mixture **P**.

L .....

M .....

N .....

O .....

P ..... and .....

[5]

(b) Write a balanced chemical equation for any **one** of the reactions described in Fig. 7.1.

.....[2]

Section B

Answer any **two** questions in this section.

Write your answers in the spaces provided.

8 **(a)** Iron from blast furnaces is usually mixed with other elements to form alloys.

Name **one** of these alloys and give a reason why this alloy is preferred to iron from blast furnaces.

.....

.....[2]

(b) In a blast furnace explain, including chemical equations, how

(i) iron is extracted from the ore,

.....

.....

.....

.....[4]

(ii) impurities are removed from the ore.

.....

.....

.....

.....[4]

9 (a) (i) Ethanol can be made in a laboratory at room temperature.

Name the process, list the substances needed and write a chemical equation for the preparation of ethanol at room temperature.

.....

.....

.....

.....

.....

.....[5]

(ii) State why the temperature of the reactants must not be allowed to rise much above 45°C.

.....

.....[1]

(b) An organic acid is formed when propanol, an alcohol, is left open to the air. Draw the structure of propanol, showing every atom and every bond.

Suggest the formula of the organic acid. Explain, with reasons, whether the propanol has been oxidised or reduced.

.....

.....

.....

.....[4]

10 **(a)** **(i)** Draw 'dot and cross' diagrams to show the arrangement of electrons in molecules of hydrogen and water.
[Proton numbers: H, 1; O, 8]

hydrogen

water

[4]

(ii) Explain why knowledge of the electron arrangements in helium and neon is important when drawing 'dot and cross' diagrams for hydrogen and water.
[Proton numbers: He, 2; Ne,10]

.....

.....[2]

(b) **(i)** Gaseous hydrogen chloride dissolves in water to produce **two** different ions. Give the chemical formula of each ion. Predict the approximate pH of the aqueous solution that is formed.

.....

.....

.....[2]

(ii) Explain why an aqueous solution of hydrogen chloride can be neutralised by adding an aqueous solution of sodium hydroxide.

.....

.....

.....[2]

October/November 2016 Paper 3

Section A

1. (a) (i) Filter funnel

EXAM TIP:

A filter funnel is used to separate a solid from a solid-liquid mixture.

(ii) Burette

EXAM TIP:

A burette is used to accurately measure the volume of liquid to the nearest 0.1 cm^3.

(iii) Gas syringe

EXAM TIP:

A gas syringe is used to accurately measure the volume of gas.

(iv) Pipette

EXAM TIP:

A pipette is used to accurately measure a fixed volume of liquid required for an experiment.

(b) (i) Simple distillation

(ii) 100 °C

EXAM TIP:

The separation occurs at the boiling point of water.

(iii) To provide a cool surface so that the vapour condenses back to liquid.

(iv) The sample collected at point A is sea water, and hence a white solid salt is obtained when heated to dryness.

The sample collected at point B is pure water, and hence no residue is obtained as all the water completely evaporated.

EXAM TIP:

The white solid left in the sample collected at point **A** indicates the presence of impurities, while no residue left in the sample collected at point **B** indicates that there are no impurities present.

2. (a) G

EXAM TIP:

The mass number (or nucleon number) gives the total number of protons and neutrons in the nucleus of an atom.

(b) E

EXAM TIP:

In an atom, electrons are arranged such that the first electronic shell can contain up to 2 electrons and the second electronic shell can contain up to 8 electrons.

(c) D

EXAM TIP:

Metal ions are positively charged.

(d) F and **G**

EXAM TIP:

Isotopes have the same number of protons but different numbers of neutrons.

(e) H

EXAM TIP:

A negatively-charged ion is formed when an atom gains electron(s).

3. (a) The elements are arranged in ascending order of proton number / atomic number in the Periodic Table.

(b) (i) Number of valence electrons

(ii) Number of shells occupied with electrons

(c) Elements in Group II have the same number of valence electrons, thus they undergo similar chemical reactions.

EXAM TIP:

Elements of the same number of valence electrons have similar chemical properties.

(d) (i) name of compound:
lithium oxide / sodium oxide / potassium oxide

chemical formula:
Li_2O / Na_2O / K_2O

(ii) name of compound:
magnesium oxide / calcium oxide

chemical formula:
MgO / CaO

EXAM TIP:

Group I and II elements are metals, while Group VI elements are non-metals. Metal atoms donate electrons to non-metal atoms to form ionic bonds.

4. (a) Add sulfuric acid to each of the three metals in a separate beaker. The reaction that produces effervescence most vigorously indicates the most reactive metal.

EXAM TIP:

Only metals above hydrogen in the reactivity series can react with dilute acids to form hydrogen gas.

(b) Aqueous sodium hydroxide solution can be added gradually into the nitrate solutions. The solution that contains copper(II) ions forms a light blue precipitate that does not dissolve in excess aqueous sodium hydroxide solution.

EXAM TIP:

The presence of copper(II) ions can be tested by observing the result from the reaction with aqueous sodium hydroxide or aqueous ammonia.

5. (a) (i) Concentration of **J** in g / dm³

$$= \frac{196 \text{ g}}{(200 \div 1000) \text{ dm}^3}$$

$$= 980 \text{ g / dm}^3$$

EXAM TIP:

$$\text{Concentration (g / dm}^3) = \frac{\text{Mass of compound (g)}}{\text{Volume of solution (dm}^3)}$$

(ii) Concentration of **J** in mol / dm³

$$= \frac{\text{concentration in g / dm}^3}{\text{relative molecular mass of } \mathbf{J}}$$

$$= \frac{980 \text{ g / dm}^3}{98 \text{ g / mol}}$$

$$= 10.0 \text{ mol / dm}^3$$

EXAM TIP:

$$\text{Concentration (mol / dm}^3) = \frac{\text{Concentration of solution in g / dm}^3}{\text{Molar mass of reactant in g / mol}}$$

(b) (i) Barium carbonate will react with acid and liberate carbon dioxide.

(ii) **K** is likely to be barium sulfate.

(iii) $H_2SO_4(aq) + Ba(NO_3)_2(aq) \rightarrow BaSO_4(s) + 2HNO_3(aq)$

6. (a) Exothermic reaction is a reaction that gives out heat energy to the surroundings.

(b) Clean energy refers to a source of energy that does not produce pollutants such as carbon monoxide or nitrogen oxides that will harm the environment.

EXAM TIP:

Some common atmospheric pollutants are carbon monoxide, methane, nitrogen oxides (NO and NO_2), ozone; sulfur dioxide and unburned hydrocarbons.

(c) (i) Relative formula mass of fayalite, Fe_2SiO_4

$= 56 \times 2 + 28 + 16 \times 4$

$= 204$

(ii) Number of moles in 1000 g of H_2

$$= \frac{1000}{M_r(H_2)}$$

$$= \frac{1000}{1 \times 2}$$

$= 500$ mol

Based on the given chemical equation, 3 mol of Fe_2SiO_4 produces 2 mol of H_2 gas.

$\therefore \frac{3}{2}$ mol of Fe_2SiO_4 is required to produce 1 mol of H_2 gas.

Number of moles of Fe_2SiO_4 required

$= 500 \times \frac{3}{2}$

$= 750$ mol

Mass of Fe_2SiO_4 required

$= 750 \times$ Molar mass of Fe_2SiO_4

$= 750 \times 204$

$= 153\,000$ g

EXAM TIP:

First, find the number of moles of hydrogen in 1000 g. Then, find the number of moles of fayalite needed based on the balanced equation given. Then, calculate the mass using Mass = Number of moles × Molar mass.

(iii) Since 1 mole of any gas occupies 24 dm³ at room temperature and pressure, volume of H_2

$= 500 \times 24$

$= 12\,000$ dm³

EXAM TIP:

1 mole of any gas occupies 24 dm³ at r.t.p. and the volume of gas in a reaction is proportional to the number of moles.

7. (a) **L** ethene, C_2H_4

M methane, CH_4

N 1,2-dibromoethane, $C_2H_4Br_2$

O chloromethane, CH_3Cl

P carbon dioxide, CO_2 and water, H_2O

EXAM TIP:

Use the molar mass of each substance to help you deduce the chemical formula of each substance.

(b) Any one of the following equations:

$C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l)$

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$

$C_2H_4(g) + Br_2(g) \rightarrow C_2H_4Br_2(l)$

$CH_4(g) + Cl_2(g) \rightarrow CH_3Cl(g) + HCl(g)$

Section B

8. **(a)** Steel.

Steel alloy is stronger and harder than pure iron metal, thus steel is preferred to iron.

EXAM TIP:

The presence of carbon atoms in steel alloy disrupts the orderly arrangement of metal atoms and prevents the atoms from sliding over each other easily. Thus, steel alloy is stronger and harder than pure iron metal.

(b) **(i)** Coke reacts with oxygen in the air to form carbon dioxide:

$C(s) + O_2(g) \rightarrow CO_2(g)$

Carbon dioxide reacts with more coke to form carbon monoxide:

$CO_2(g) + C(s) \rightarrow 2CO(g)$

Haematite is reduced by carbon monoxide to form molten iron, which is collected at the bottom of the blast furnace:

$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(l) + 3CO_2(g)$

(ii) Limestone decomposes at high temperatures to form calcium oxide:

$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

Calcium oxide reacts with impurities such as silicon dioxide to produce calcium silicate (or slag), which is removed from the blast furnace:

$CaO(s) + SiO_2(s) \rightarrow CaSiO_3(l)$

9. **(a)** **(i)** Process: Fermentation

Substances needed: Glucose, yeast

Chemical equation:

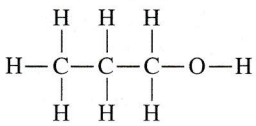
$C_6H_{12}O_6(aq) \xrightarrow{\text{yeast}} 2C_2H_5OH(aq) + 2CO_2(g)$

EXAM TIP:

Fermentation occurs naturally in yeasts to produce ethanol.

(ii) If the temperature is too high, the enzymes in yeast will be denatured and unable to catalyse the reaction.

(b) The structure of propanol:



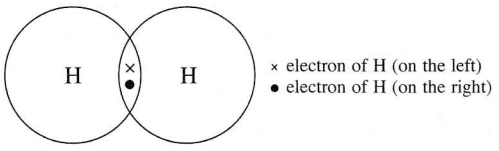
The formula of the organic acid is C_2H_5COOH.

Propanol has been oxidised to form the organic acid as there is a gain of an oxygen atom in the structure of the organic acid.

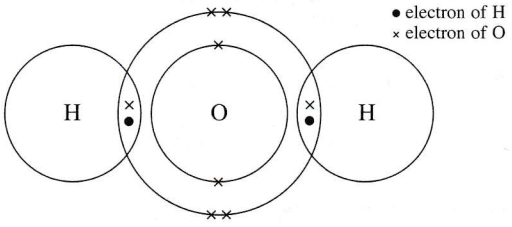
EXAM TIP:

Alcohols are oxidised to form carboxylic acids.

10. **(a)** **(i)** hydrogen



water



EXAM TIP:

The H atoms in hydrogen are bonded by a covalent bond. The O and H atoms in water are bonded by covalent bonds.

(ii) The electronic configurations of helium and neon are stable. Thus, hydrogen and oxygen atoms form covalent bonds in order to achieve the same stable electronic configurations.

(b) **(i)** Ions produced: H^+ and Cl^-

Predicted pH: 1 – 2

EXAM TIP:

When gaseous hydrogen chloride dissolves in water, hydrochloric acid (HCl) is formed.

(ii) Sodium hydroxide ionises completely in water to form Na^+ and OH^- ions. Thus, the OH^- ions are able to react with H^+ ions in hydrogen chloride to form water.